UITP ADVANCING PUBLIC TRANSPORT

REPORT

DEMYSTIFYING TICKETING AND PAYMENT IN PUBLIC TRANSPORT

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INTRODUCTION

Ticketing and payment systems are key elements of a public transport system. Technological advancement has helped systems evolve dramatically over recent decades. However, things have gotten complicated for public transport operators and authorities. Twenty years ago, it was just a matter of choosing the tariff scheme, the technology, to design the system depending on passenger flows and finally to choose the supplier. In other words, the ticketing integrator that would take charge of the whole project to deliver a turn-key system. Nowadays, the challenge starts with trying to understand about closed-loop versus open-loop, card-centric vs system-centric, prepaid vs post-paid, account-based ticketing, open payment, SIM-centric mobile ticketing, Secure Element, HCE, interoperability, multiservice, beacons, NFC, QR code...and so on.

The objective of this report is to demystify these concepts by:

- *Clarifying the current landscape of ticketing and payment in public transport*
- *Detailing the different technologies and solutions on the market*
- *Describing the different systems and business models*
- *Looking ahead to relevant emerging trends in the mobility sector*

Ticketing exists due to the need to establish a contract between passengers and transport operators but also because transport is not a good that can be purchased like any other good; ticketing is the gateway to mobility and the freedom for all to move about[1].

1 Inspired by article from Philippe Vappereau, Calypso Networks Association.

A BRIEF HISTORY OF PUBLIC TRANSPORT TICKETING

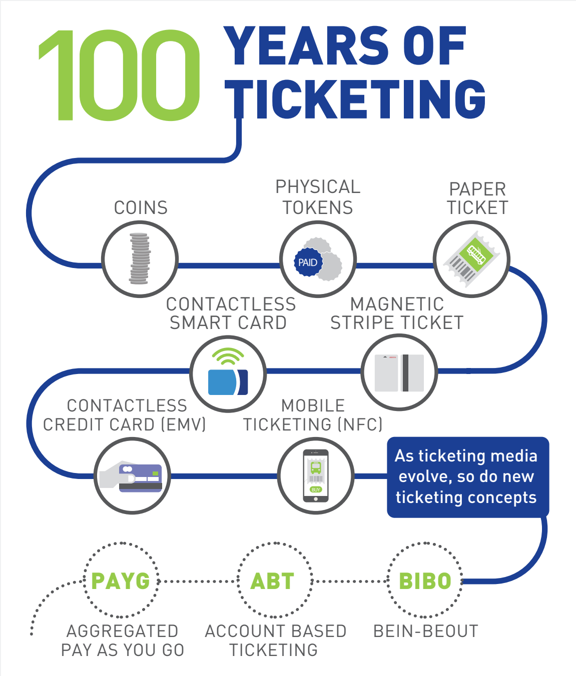
From the 1950s to the late 1980s, single medium systems such as tokens, paper or magnetic stripe tickets were generally used. During the 1990s, ticketing started a transformation process made possible by the emergence of new information and communication technologies (ICT) such as location services, real-time passenger information services as well as contactless smartcards. This technological revolution in ticketing has been creating significant improvements from a user experience perspective, and a new era of marketing opportunities for public transport authorities (PTAs) and operators: the contactless smartcards have supported in developing a strong relationship with customers, knowing them and better understanding their needs.

Well known smartcard schemes include Oyster (London), Octopus (Hong Kong), Navigo (Paris) and Suica (Japan). In these schemes, the travel information and the rights to travel are stored physically within a chip embedded in the card itself: memory size, microprocessor security and contactless performance are key to the success of this technology.

Thanks to the rapidly changing telecommunication technologies, the next innovations centre around two main concepts:

- Leveraging existing 'items' already in the traveller's pockets, ubiquitous enough not to be issued by the transport operator. The two main devices today are the contactless credit cards and the smartphone: this is often referred to as 'Open Loop', as opposed to 'Closed Loop' systems, where a proprietary media must be acquired. However, there are few exceptions like use smart phones also in closed loop configuration (e.g. Hong Kong).
- The launch of 'account-based' ticketing systems give a greater degree of flexibility, both from a traveller convenience and operational performance perspectives: Transport rights are stored on a central system, not on a customer card. Software processing no longer takes

place on front office equipment (validators, vending machines, ticketing inspection devices) but on the central system instead. The customer 'device' becomes simply a means of identification where no data is stored.



Source: UITP & Messe Karlsruhe for IT TRANS

Interestingly, the whole spectrum of medium and systems can be found simultaneously in the market: Technological innovation in ticketing does not necessarily lead to the most basic systems being made obsolete. Tokens, paper and magnetic stripe tickets continue to be deployed and it will be many years before they are phased out. The same is true for contactless equipment or cards, as the PTA investments are not yet written off. One innovation does not replace the previous one!

THE CURRENT LANDSCAPE

KEY CHALLENGES

The chasm between city and suburban or rural life continues to widen as the technological revolution focuses on maximising outcomes for dense communities. To ensure no citizens are left behind, solutions must scale in either direction. Ensuring equitable experiences across age, demographic, and personal choice is difficult but a necessary ingredient as we move toward new standards for interoperability and data sharing. Considerations of data for privacy, confidentiality, and Personally Identifiable Information (PII) are expected by users but are not well defined in any universal standard. Currently, decisions are made in siloed organisations across government but increasingly touch multiple facets of the value chain of government services. At the same time, private mobility providers have emerged making seamless ticketing even more difficult across the public and private divide. This creates opportunity for new approaches to coordination but willingness to forgo any part of individual control of that ecosystem is a difficult proposition.

CURRENT DEMANDS

Growing urbanisation, rising consumer expectations, and changing demographics together with declining government funding streams have created a perfect storm in the traditional provision of service for public transport. Private innovation lead by venture capital funding has brought new focus to the value of mobility. Public transport was traditionally, and in some places still is, a function of government, sometimes offered through contract service to private providers, but is receiving new attention as technology creates potential business models attractive to new players. While adding complexity to the system, private mobility service providers offer new alternatives that could expand the user base of public transport. The potential danger in this is that the role of government to make decisions in favour of the public good should not be abdicated in favour of capital market opportunities. Impacts on environment, congestion, health, and quality of life must be considered as part of a holistic, people-centred solution.

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Within this array of challenges lies hope in a future that improves on the lives of all citizens. Ticketing is no longer a simple part of the public transport experience, it is what enables freedom of movement across modes and borders. With emerging models such as Mobility as a Service (MaaS), account-based systems can connect movement in a region with new opportunities for reward programmes, loyalty toward preferred modes, and access to recreation, entertainment, commerce, and employment. Shifting 'service-consumed' business models among providers does not currently align to types of available funding options. However, with every challenge there is equal opportunity, the specifics of which are further explored in this Report.

SMART TICKETING

CARD-CENTRIC OR MEDIA-BASED TICKETING

A card-centric scheme is a fare collection system in which the funds, proof of entitlement to travel and any primary records of travel are held directly on the card. All front-end equipment in a card-based system must be able to update travel records and/or perform fare calculations directly to the card each time it is presented:

- During the validation process, the validator/terminal checks that the card is genuine, and that appropriate rights/value are present.
- The validator also updates the data on the card and such card-terminal transactions are secure and instantaneous.
- Media-based ticketing (MBT) schemes can work offline, and failure of telecommunication has no impact on validation or even on loading.

In many ways, the card centric solutions have become de-facto standard for public transport payments over the past three decades, because they have a number of advantages over even older paper-based systems. Smartcards are more flexible, secure, easy-to-use and have reduced operating costs, compared to paper tickets.

Main characteristics of MBT

- Validators/terminals need a certain level of intelligence to perform complex functions
- Upfront infrastructure investments
- High operational costs, due to the need to maintain proprietary infrastructure (although new solutions are emerging to avoid this)
- Resilient to network failures
- Integration with third-party systems is often more complex and costly
- Data synchronisation is complex due to the distributed nature of the system and it can take a long time before updated data gets distributed
- Losing a travel card means a loss of funds or travel rights on it, unless it is managed by the system through the personal account
- Ensures the best protection for the customer in matters of privacy and respect of GDPR
- Avoids the negative impact of heavy data servers and communication networks on energy balance

In many cases the customers are forced to use dedicated hardware for top-up or ticket purchase, making the whole process slow and inconvenient. There are also significant costs for issuance and management of proprietary travel cards. Nowadays, MBT is adapting to the digital experience, expected by the customers, and mobile add-ons are increasingly possible, hence bringing a significant improvement in terms of convenience to the customers.

LONDON, UNITED KINGDOM

When the number of passengers on the London Underground rose dramatically in the 1990s, Transport for London (TfL) had to find ways to get people through the entrance turnstiles at metro stations faster. TfL decided to invest in new technology and the contactless travelcard Oyster was introduced in 2003.

The card can hold single and period tickets as well other travel permits, which all must be added to the card before travel. It is used in the Greater London area on various travel modes, including the underground metro, buses, light rail etc.

By 2013, more than 60 million Oyster cards were issued and over 85% of all rail and bus travels were paid for by Oyster.

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ACCOUNT-BASED TICKETING

Account-based ticketing (ABT) is a fare-collection system in which the proof of entitlement to travel and any records of travel are held in a back-office (i.e. servers) and not necessarily on any physical media held by the passenger.

ABT differs from traditional card-based schemes because the business rules and fare calculation are managed in the back-office and the fare is calculated and billed after the trip is complete. This means that the fare-media used to tap in and out of the system is nothing more than a unique identifier for the customer linked to their account.

The main characteristics of ABT:

- Media Acceptance Devices (MAD)/validators usually do not write any data on physical media, which means that the card is no longer the master of all data. But it remains fundamental that the card is authenticated. Otherwise, the customer is not protected and his rights stored on the central server can be used by another person.
- Lower set-up and operational costs: No need for heavy infrastructure, reduced costs for cash handling.
- Possibility to accept additional tokens than the ones issued by the operator.
- Meeting the growing consumer demand to use the same convenient ways to pay for mobility as for other daily expenses.
- Good service for customers: Less congestion and improved customer experience.
- Easier integrations with third parties such as MaaS schemes, sharing economy, Park & Ride.
- Interoperability: If an open-loop global standard like EMV is implemented, then it enables the use of same media in various transport networks.
- Central servers for data management represent a weakness, with examples of data intrusion (hacking) demonstrating the strength of this risk.
- In case of non-existing communication, the granting of access is linked to a potential loss of revenue.

ABT can operate in both an online and offline world, using risk-managed revenue protection techniques as appropriate. The system is regularly updated, and the frequency of data synchronisation depends on the network capabilities and ABT system technical configuration.

TALLINN, ESTONIA

Tallinn was one of the first cities in the world to implement ABT. The system was launched in 2004 with every valid Estonian ID-code holding citizen able to buy tickets and season passes online and via mobile phone. The travel rights were stored in the ABT system's back-office and checked against the person's ID card with handheld devices on the vehicles by ticket inspectors. Since then, Tallinn has upgraded its ABT system several times, introducing self-service validators with closed-loop travelcard, contactless EMV and 2D code acceptance, but also multiple integrations with other city services, like Park & Ride and tourist sightseeing packages.

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Hybrid solution

For more complex conditions and larger systems, a hybrid solution architecture can be used. This means that although the travel right is still stored in the back-office, the information is also written to the card itself. Balances on the card and in the back-office are compared and verified during synchronisation. In large systems the amount of data is too big to be constantly synchronised to all vehicles and such a hybrid approach provides faster validation and mitigates financial risks for the PTA.

Key statements to consider:

- It is possible to have ABT with both open-loop and closed-loop cards
- It is possible to have ABT with or without EMV

MIGRATION SCENARIOS

In this section migration refers to a transition from a card-based ticketing scheme to an ABT solution, where no monetary or ticket data is written on the card. There are numerous scenarios available that depend on the size of the project, readiness for cooperation of the current system provider and other factors that drive the migration strategy. Some examples include:

- Overnight go-live with parallel installation of equipment
- Gradual go-live with temporary data-writing on the existing cards by the new ABT system
- Gradual go-live with back-end to back-end balance transfer between the systems
- Free ride period during installation and go-live period

The migration scenario and execution design should be agreed between the PTA and supplier during the project plan development phase. **Continuity of ticketing services is paramount: the migration should be planned carefully to allow a smooth experience for customers and operators whilst introducing new functionality and replacing existing systems in a controlled and risk managed process.**

Replacement of the ticketing equipment

Although there are examples of good cooperation, in most cases the willingness to cooperate from current solution providers is low and not outlined in existing contracts. Thus, the new ABT solution normally cannot utilise existing card structures nor hardware and a new set of validation devices needs to be installed. Depending on the chosen scenario, existing h ardware can be replaced all at once, gradually or installed in parallel, having two sets of validators on vehicles. Gradual replacement generally means that there must be a periodical data transfer between back-offices of both systems, or temporary writing on the cards (limitations apply on IP of the card structures). If the vehicle number is too high for the 'all at once' option, then gradual replacement causes the least confusion for passengers, as there will be only one set of validators on the vehicle.

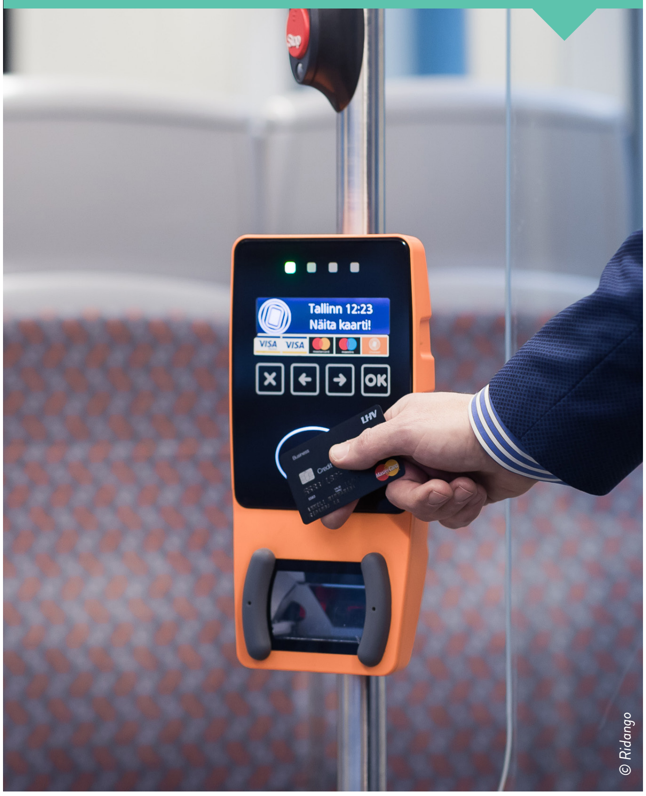
Migration of existing tokens and balances

Regarding tokens, the easiest way is to issue all new tokens and phase out existing cards. However, this implies that all customers need to obtain a new token. This may cause inconvenience for customers, but also a substantial workload on card issuing and distribution network. Thus, the smoothest transition is to start using existing cards as tokens. The list of existing card numbers can be imported into the new system and, depending on the card type, availability of cryptographic keys and data written on the card, the cards UIDs (Unique Identifier) or other information would be used to access the account, connected to the card.

KLAIPEDA, LITHUANIA

Klaipeda has had a card-based electronic ticketing solution since 2006. In 2017 the tender for an ABT solution was launched and it was decided from the beginning of the project that all existing travel cards should continue to work in the new system. As the cryptographic keys for issued cards were not available, card UIDs were used to import all existing cards into the ABT solution as tokens. On the night of go-live, all card balances were transferred to the ABT back-office and, using parallel installation of ticketing equipment, the overnight go-live was executed.

As the card type is not the most secure one, the system has several fraud prevention functionalities including monitoring the number of validations in a certain time period and card movement speed. The fraud risk cannot be fully eliminated, but considering the economic value of the possible fraud, the convenience for customers outweighed the risk.



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VALIDATION TECHNOLOGIES AND TICKET CARRIERS

Paper tickets are a traditional, but still widely used means, which have been used since as early as the 1840s. They are often still in used in parallel with more modern carriers. The details of validity (data) are written or typed or printed onto the ticket. They can be single, multiple use, or season tickets. They are purchased in advance or at the time of journey from the driver, and are disposed of once their validity is expired.

Single and multiple use tickets may be subject to validation through on-board validation machines, or on inspection by a staff member. Season paper tickets are generally not subject to physical validation.

Paper tickets in some long-standing public transport networks are considered iconic. The main advantages of paper tickets lie in their simplicity. On the other hand, disadvantages include susceptibility to fraud, counterfeit as well as identity fraud by travelling using another person's season ticket.

Magnetic stripe cards, also known as swipe cards or magstripes, are effectively an early smart card on which data can be stored and read by a machine. They have been common in public transport since the 1970s.

They are typically paper tickets or plastic cards featuring a band of magnetic material which stores the data. Apart from ticketing in public transport, they are common in credit cards, ID cards, hotel room keys and so on.

Advantages of magnetic stripe cards include product cost efficiency and reusability. In the public transport environment, they can be read and processed by validators. Disadvantages include the cost of maintaining the equipment and the fact that the magnetic stripe can be relatively easily damaged, proximity with magnetic fields can render them unusable and only limited data can be stored on them. Counterfeit can also be an issue.

For magnetic stripe cards several ISO standards are relevant: ISO/IEC 7810, ISO/IEC 7811, ISO/IEC 7812, ISO/IEC 7813, ISO 8583, and ISO/IEC 4909. These standards define the physical properties of the card, including size, flexibility, location of the magstripe, magnetic characteristics, and data formats.

CONTACTLESS SMART CARDS

A smart card is a device, generally bank card size (standardised format), made of an embedded integrated circuit encapsulated in a plastic body. The contactless smart card communicates with and is powered by the reader through radio-frequency (RF) induction technology, within a few centimetres distance. It is a miniaturised computer with its own computing power and applications.

The contactless smart card is a durable support with a life span of many years. It is secure, affordable and can be used for many services: the same smart card could be used for public transport, payment services, loyalty, and so on with a dedicated application for each service.

Public transport contactless smart cards

Globally, contactless fare collection systems are basically used for efficiency in public transport: Validation transactions must be secure, and above all, fast. All equipment, even on-board equipment like validators, are autonomous and able to make decisions on their own. This is mainly because at the time this technology was developed, there were no possible real-time connections with a distant ticketing server where most part of the intelligence could have been located.

The smart card is used to hold ticketing data (loaded value, tickets or passes) in a secure way and every transaction (product loading or validation) is done through an encrypted secure session. Several formats were created to meet this need, some proprietary (e.g. MIFARE) and some others open (Calypso, CiPurse), and all of them being too different to be compatible, despite standardised RF communication. In some countries, this has led to monopolistic situations and consequently an explosion of costs associated to the implementation and maintenance of such systems.

In addition to public transport cards, many cities have launched 'city cards' for visitors to provide convenient public transport but also entry to major attractions and events, and discount for certain venues or services

Online remote loading is a feature of ticketing systems allowing customers to buy and load tickets and passes on their smart card remotely: On their personal computer using a smart card reader and a website. In addition, customers now can use their smartphones for the reloading of cards.

The website has the same feature as a ticket vending machine for reloading smart cards. It can read and display the content of a smartcard, the customer can then choose a ticket/pass, buy it with a credit card and have it loaded on the smart card remotely.

This service can be convenient for customers who buy tickets frequently or for multiple smartcards (e.g. a parent buying tickets for other family members). However, a smartcard reader is necessary, generally available at sales agencies for an affordable price. Moreover, this system is difficult to maintain for the PTA which must provide specific versions for each operating system and browser and do frequents upgrades.

A contactless bank card is a smart card issued normally by a bank against a depositary account to provide services such as withdrawals or payments. The change in the balance of the account can be immediate or at regular intervals for credit cards.

When a bank card is used on a public transport network, it is typically a contactless bank card, with an embedded near field communication (NFC) chip. There are two primary ways to use a contactless bank card to pay for transit:

- Pay-as-you-go: In this case the passenger taps the card on the card reader at the time of entry or at the time of entry and exit (the requirements vary from system to system) and full fare is deducted for each ride from the cardholder's bank account;
- Payment using passes and public transport fare values stored on the card: In this case, the bank card contains, in addition to the bank application, a public transport application. It is then "seen" as a public transport smart card on ticketing devices and may be loaded with tickets/passes.

TICKETING STANDARDS

Smart Ticketing Alliance

The Smart Ticketing Alliance (STA) is established to support the development of interoperable Smart Ticketing. The STA goals are:

- Co-operation between national and regional smart ticketing schemes
- Develop, agree, publish and promote requirements for smart ticketing interoperability
- Co-operation for the establishment of trust schemes, specifications and certification
- Liaisons with relevant European and international bodies to promote interoperability

The Smart Ticketing Alliance is a direct follow-on from the EC FP7-funded Interoperable Fare Management Project[2]. The STA is an international non-profit distributing association under Belgian law (AISBL). The STA was founded in 2015. Founding members were UITP, Calypso, ITSO (UK), AFIMB (France) and VDV eTicket Service (Germany).

For a cross network or multi-modal journey, or one crossing multiple borders, there are two options open to the operators involved: to offer the customer the simplicity of holding just one single ticket for the entire journey; or to offer separate tickets or tokens for each sector of the itinerary held in a secure Smart Ticketing Wallet. A further option is to provide the customer with a unique token that allows travel in all participating networks and the customer is billed later when the trip is completed (Account Based Ticketing).

2 For more information: www.ifm-project.eu

The Smart Ticketing Alliance has published the open specifications necessary to allow Smart Ticketing Wallets and tokens to be used across border, across scheme and across mode. It is working in alliance with the NFC Forum (representing mobile handset manufacturers), the GSMA (representing Mobile Network Operators), GlobalPlatform (representing chipset manufacturers) and CEN/ISO to bring about harmonisation of specifications with regard to Smartcard and NFC technology for the public transport industry.

Smart ticketing originated from the wish to have interoperability between upcoming regional and national public transport electronic ticketing systems. To achieve this, the STA focus has been on the customer media while allowing for the concept of dynamic and multiple applications. The STA has intensively been working to define the many use cases for integrated ticketing and how these may be loaded and securely stored on the customer's preferred contactless media or serviced by an ABT solution.

Recent STA achievements have been realised in terms of certification. As it is essential that public authorities and users can be confident in the quality of contactless communication between contactless readers and fare media, certification is the appropriate means to give trust. The STA certification program established by STA consists of a Group of Certification Bodies (STA GCB) bringing together certification bodies authorised to certify compliance of transportation and acceptance media with the CEN technical specification TS 16794 about contactless communication[3].

ITSO Limited

The ITSO Specification is the British open national standard for smart ticketing. The specification was developed with the aim of ensuring that PTOs throughout the United Kingdom can develop compatible smart ticketing systems. That means that, where necessary or desirable, different operators' smart ticketing systems can 'talk' to each other so that a passenger can use just one smartcard no matter which operator is providing the service or where the ticket was purchased. ITSO also assures the integrity of its members' transport smart ticketing schemes through the ITSO security management service (ISMS) which underpins them.

ITSO Ltd is a non-profit membership organisation which aims to make travelling on public transport throughout the United Kingdom seamless and easier by using smart technology.

ITSO smart ticketing schemes have been in operation across United Kingdom since 2002. Public transport authorities first established the smart processing of concessionary bus passes using ITSO-compliant technology (English National Concessionary Travel Scheme) with many commercial schemes following and continuing to grow today. Across concessionary and commercial schemes, across different modes of transport, there are over 16,5 million ITSO smartcards, making over two billion journeys every year. ITSO also operates a testing service to certify smart ticketing equipment to ensure it meets the ITSO Specification. Working with technical experts in both the transport, mobile and wallet payment industry, ITSO are leading the development of ITSO on Mobile – an end to end mobile ticketing solution that delivers secure ticket fulfilment within the trusted ITSO environment.

ITSO is an active participant in several relevant committees of both CEN and ISO. ITSO also uses standards issued by other standards making bodies such as the NFC Forum and Global Platform.

CALYPSO Networks Association

Calypso is one of the globally adopted ticketing specifications providing a solution suited to transport and mobility needs. Widely distributed and field proven in more than 215 schemes in 25 countries around the world with more than 150 million portable objects on the field. Successfully running schemes include Lisbon, Paris, Milan, Venice, Turin, Montreal, Mexico, Riga and several countries like Belgium, Latvia, Algeria, Morocco and Israel. It is an open technology, free from any manufacturing monopoly making it both economical and adaptable to evolving future technology changes. Calypso offers a standardised and multi-application solution while preserving individual data protection.

Calypso can be regarded as a set of technical specifications describing a fast and secure contactless transaction between a terminal and a portable device. Technologically it represents a coherent aggregation of its specifications with the use of all existing standards. With CNA, a Belgian non-profit association, the users decide on the evolutions of the specifications and of the security, ensure that the specification remains open, with no monopoly and an extensive panel of providers.

3 More information on the STA can be found under www.smart-ticketing.org

Through Hoplink, Calypso can provide an interoperability solution that is adopted in many regions and agglomerations in France and on a cross border level between French and Belgian regions. Hoplink is a scheme of interoperability based on the principle that interoperability is based on media and not of tariff or commercial nature.

In order to better reflect the market challenges CNA has developed since 2017 an Open Source API for terminals, called Keyple. It manages all generic and necessary commands to process smart cards or any other NFC contactless object commands. It is completely free, modular, compatible with various OS (Windows, Linux, Android), delivered with various pluggins (OMAPI, PC/SC, NFC..) and languages (Java and C++). The SDK is available through the Eclipse foundation. To complement this evolution in terms of sustainability and necessary trust, CNA provides a certification scheme[4].

LISBON REGION, PORTUGAL

Since 2003, the metropolitan region of Lisbon has been developing, though a Consortium of public and private operators (OTLIS) an open interface and open architecture ticketing system, based on Calypso Standards, but being able to to integrate with different card schemes, hybrid banking cards and EMV enabled cards and mobile payment applications. This allowed multiple ticketing operators, hardware providers, vendors and card issuers, under an interoperable ticket architecture. It made possible the integration with the national rail service (CP) and the addition of other regions and operators willing to agree with *OTLIS standards.*

VDV eTicket Service

The standard for electronic fare management (EFM) valid in Germany is the VDV Kernapplikation – in short: VDV-KA. It is an open standard which was developed as part of a research project initiated by the Federal Ministry of Education and Research (BMBF) and completed in 2005.

The VDV-KA has created a common technical basis for German public transport in the long term. During the development of the VDV Kernapplikation it quickly became clear that there must also be central background systems for the communication of the individual EFM systems, which are set up locally by the transport companies and associations. In the context of the complexity of IT security, it also became apparent that the entire security management for eTickets cannot be implemented locally but must be operated from a central location.

The VDV (((eTicket Service, which was created by the Association of German Transport Companies (VDV), among others, now operates and coordinates this technical platform for electronic tickets under the name (((eTicket Deutschland. Every participant has the possibility to choose between different expansion levels of the VDV-KA.

The preferred user medium on which an (((eTicket is stored is the smart card. In total, more than 13 million contactless smart cards are currently used in Germany. Also, smartphones play an increasingly relevant role for eTickets and related information and additional services. The VDV barcode for issuing mobile phone tickets was taken into account right from (((eTicket Deutschland outset. If some security-relevant aspects are clarified, the mobile phone ticket will be able to catch up with the smart card and completely different user media can also be considered. The possibility of networking between transport companies is always available and multimodal options such as the integration of bike sharing, car sharing or even tickets for car parks, zoos or concerts can also be implemented.

4 More information can be found on www.calypsonet-asso.org and www.keyple.org

"Travelling across the border with only one ticket – the easyConnect project sets up an interoperable account based ticketing solution between Germany and the Netherlands. Taking the train from Aachen to Maastricht while having the ticket on your smartphone paves the way for real seamless traveling without even noticing there is a border."

EXAMPLES OF OTHER CARD SCHEMES

Sydney, TfNSW: contactless smart card (Opal), stored value, wide area multi-modal system covering Greater Sydney and adjoining conurbations. Features check-in, check-out methodology and a wide range of concessions. Recently added EMV and mobile ticketing to extend the system functionality.

Japan, nationwide: pre-paid e-money contactless smartcard (Suica) for travel and shopping across many regions of Japan, interchangeable with Pasmo gives access to High Speed Rail network and some taxis. Suica card widely accepted at popular retail outlets. Mobile application available and since 2016 virtualized card on apple devices.

Hong Kong, MTA: (Octopus) one of the first smartcard systems deployed worldwide in 1997, stored value, used for fare collection on multi-modal public transport network and retail sales across Hong Kong. Scheme is accepted by limited number of taxis, new mobile app for drivers will expand usage. Limited use of cards in Macao and Shenzhen.

Canada, Montreal & Quebec, (Opus) stored value contactless smart card using Calypso standard. Seamless integration across multiple neighboring multimodal transit systems.

Portland, TriMet: contactless smart card (HOP-fast), interoperable among 3 regional authorities, multi-modal, includes on-demand and bike-sharing services. Open architecture account based system and features EMV, Mobile ticketing, inc. virtual card, cash, hanger cards, mobile pay apps and best fare/fare capping.

Denmark, nationwide: contactless stored value smartcard (Reijsekort) system allows seamless multimodal journeys for passengers, features check-in, check-out on all journeys to calculate fares. Scheme works with anonymous pre-paid and registered post-paid options with discounts for volume usage.

Vancouver, Translink: multimodal stored value smartcard (Compass) operates seamlessly across regional transit network. Recently added EMV capability and mobile pay apps check-in, check-out to transfer and calculate fare zones used.

Moscow, MTA: region wide contactless stored value smartcard (Troika) for all modes, various discount schemes for volume usage. Recently addition of mobile ticketing and hanger cards plus use of cards for parking and bicycle hire.

Singapore, LTA: early adopter of contactless smartcard (Easylink) technology, stored value card system across multiple modes, may also be used as payment card at limited outlets. Tap-in, tap-out used for fare calculations. From 2006 additional card from NETS added and interoperability achieved for both cards. Mobile applications and EMV technology being deployed.

Cape Town, MyCiTi, contactless top-up using pay wave EMV cards (**my**connect) using check-in, check-out for fare calculation. Used across new bus rapid network, plans to integrate with rail network (long term strategy to use cards in other South African cities).

Bogota, Transmilenio: contactless stored value smartcard (TuLlave) across multimodal regional transport network. System features discounting and numerous concessions.

EXAMPLES OF OTHER CARD SCHEMES (cont)

London,TfL: multi-modal contactless stored value smartcard (Oyster) and EMV (more than 50% of users) schemes that cover the Greater London region. Check-in and out technology for calculating fares across the network. Features capping, concessions, online and mobile top-ups and payment by mobile payment apps.

The Netherlands, nationwide: stored value contactless smartcard (OV-chipkaart), originally in Rotterdam but now covers multimodal national network. Network based on check-in, check-out to calculate fares. System features single use, anonymous and personalised cards allowing multiple fare and discount options.

Chicago, CTA, system features cash and contactless stored value smartcard (Ventra) also allows mobile payment apps, supports mobile app and EMV is supported across multimodal network. System features concessions and a variety of period passes.

Sao Paulo, SPTRANS: system features a proprietary SAM and Card Scheme, owned by the Transport Authority (SPTRANS), allowing multiple device providers and multiple credit vendors. System allows multiple tariff models with time and modal integration, acting as clearing house for multiple operators.

SUPPORT FOR MEDIA AND MOBILE DEVICES

1D/2D barcodes

There are several widely used standards for 1D/2D codes – a simple one-dimensional barcode, QR-code and Aztec code being perhaps the most common ones. Depending on the printing capabilities at the points of sale, the 1D/2D codes can be printed out and used in a form of a paper ticket, but in the context of the current paragraph, a mobile ticket in a form of the 2D code is considered.

After downloading a mobile application from the transport operator or from a service provider, the users will be able to purchase the tickets in the form of 2D barcodes. The payment can be done using a credit card or others payment solution available in the app.

As 2D codes are already used in various areas and widespread in the entertainment sector (concerts, sports events etc), people are familiar with this digital ticket carrier and have mastered the usage. Moreover, as most mobile phones are already able to display 2D codes, this solution becomes more and more universal.

The main weakness of 2D codes is that they can easily be reproduced by a simple screenshot of the user's phone screen or copied paper ticket. To make it more secure, 2D code needs to be combined with others security mechanisms. For example, an animation can be displayed during the validation to avoid usage of simply copied screenshots. It is also possible to enable static 2D codes for a single use ticket product only and expire the code after validation.

For a more sophisticated approach a dynamic (rolling) 2D could be used. This means, that the 2D code in the mobile application changes periodically according to a specific algorithm, which is also implemented for validation process. This security measure allows using 2D codes also for high value period passes with a minimum exposure to fraud.

The popularity of 1D/2D code usage in public transport varies heavily in different regions. For example, Sweden has agreed on a national standard for compiling an Aztec code for public transport use and it has become a normal everyday validation. On the other hand, in many countries 2D codes are considered to be an obsolete technology for public transport purposes.

It is, however, a simple and cheap way to start using mobile phones in public transport ticketing and validation. Depending on the validation method and local regulations, purely inspection based visual validation could be implemented without additional costs for vehicle equipment. Alternatively, specific 2D readers should be installed in public transport vehicles for self-service validation. The duration of the transaction with 2D codes, however, is rather slow and this can harm the necessary flow of passengers. Another potential risk is the rather easy way to damage with malicious intentions the validators or other equipment.

MOBILE NFC

NFC technology is used on the majority transport networks, which have done the investment to support the contactless cards or tickets. To benefit from the service, the user downloads a mobile app from a store. In a second step, a digital card is created in a secure space on the smart phone. No longer tied to issues related to plastic card distribution, the whole range of tickets can be sold anytime and anywhere. To validate or to be controlled, it is simple and fast: the user validates his/her smart phone on the equipment.

NFC technology presents two big advantages:

- It reuses the equipment in place. It means that PTOs don't need to invest in an additional equipment for validation or control operations;
- It reproduces the same travel experience. The user uses its smart phone as a contactless transport card, it is simple and fast. Moreover, the transport operator transfers the ownership of the medium and no longer has to manage the life cycle of the plastic cards (creation, loss, theft, replacement).

Until recently, two limitations have slowed down the spread of the NFC mobile ticketing:

- Until some years ago, NFC technology was not implemented on all smart phones as was Bluetooth or WIFI, and had suffered from problematic implementation by some mobile manufacturers which would prevent the good use of the service. But in the last three years, driven by a strong payment market, the NFC standardisation on mobile has rapidly improved the performances and the spread of NFC technology into the entire smart phone range. Moreover, the native integration of NFC API in the Android version 9 contributes to an even harmonised NFC mobile performance.
- Apple phones do not provide an open NFC architecture. For the Japanese market, Apple has decided to integrate the transport card Suica in September 2016 as well as Shanghai, Beijing and Portland, with signals that may indicate pursuing markets in other regions.

MOVINGO

Movingo is the brand name for Mälardalstrafik MÄLAB AB, operating trains in Stockholm and surrounding counties in Sweden. The Movingo mobile app for ticket purchase was launched in 2018 and it is the first ever implementation of Swedish national standard for ticketing and payment – Biljett- och Betalstandard (BoB).

When buying a train ticket for travel through several regions, the Movingo central system sends queries, based on BoB standard interface, to ticketing systems of all named regions and bundles the responses together to a single Aztec code, which can be inspected by the revenue protection officers, but also used for validation in other modes of public transport in the counties, which ticket product is included in the bundle.

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There are currently two ways of storing and securing the information:

- Within a physical part of the smartphone called a secure element (or SE). As with a bankcard, the information is stored and secured within the chip. This method is the closest to that of the contactless card currently used in transport systems. It is therefore directly compatible with existing contactless equipment. It is also the one used by iOS solutions. It allows transactions to be carried out (validation or control) even when the phone is switched off or out of battery, which is a major benefit to the customer experience.
- Within part of the software of the phone called Host Card Emulation (or HCE). This method, which is offered by Google, is principally compatible with Android phones. It currently offers the widest compatibility with Android phones as no prior agreement with SE suppliers, mobile operators or manufacturers is needed.

These two different systems have been the subject of much debate between experts. The future may decide in favour of an intelligent cohabitation between these two NFC technologies according to local needs.

PARIS REGION, FRANCE

Since the NFC mobile technology was introduced in the payment market (payment transactions are set to jump from 15% in 2017 to 53% in 2022), its implementation in the public transport market is now at the top of the agenda. In the Paris region, the PTA Ile de France Mobilité, carrying one of the largest public transport-riding populations in the world (8.5 million journeys/day), have launched in September 2018 an NFC mobile solution to sell their tickets and passes, without any impact on the MBT system infrastructure.

SMS

The user sends a message (short code or text) to a number and receives an SMS that displays travel and control information and the validity period. Usually the ticket must be used during a short period immediately following purchase. Depending on the code sent, different tickets can be purchased: for example, a single ticket or a daily ticket.

This solution is simple to use and can be used with all types of mobile phones. It allows buying a ticket anywhere at the last moment and the payment is handled directly via the user's mobile operator subscription. This solution is convenient for occasional travelers and has proven a real success where it has been deployed.

Nevertheless, the system provider has to conclude a partnership with each mobile operator, so the solution is often limited to major local mobile operators. Moreover, usually only tickets with immediate departure are sold so the fare collection is restricted. Also, the distribution cost is generally very high (could be between 8%-10% of ticket price) and transport operators therefore don't have much interest in promoting such a solution.

BE-IN/BE-OUT (BiBo)

For the last 30 years, most of the fare collection industry has been relying on proximity smartcard-based Check-in/Check-out (CiCo) validation solutions. Meanwhile, seamless method called Be-in/Be-out (BiBo) have been tested and trialled for nearly 20 years.

The main difference between CiCo and BiBo solutions is the way passengers identify their travel account:

- In Check-in/Check-out (also called Tap-in/Tap-out or Touch-in/Touch-out) method, they would need to present their fare media/token to a specific Media Acceptance Device (MAD) / validator that uses a short-distance reader to check the passenger in to the transport vehicle/network.
- In case of BiBo scheme, the physical validation infrastructure within transport vehicle automatically detects the appearance and disappearance of a specific electronic token carried by passengers, without them needing to take any specific action. It enables a truly "hands free" travelling experience

BiBo schemes are only suitable for use in honour-based non-barred transport systems, where passengers don't need to prove their ticket availability. Enforcement of the payment is either fully honour-based or by random inspection. For barred transport environments, the hands-free experience is being experimented by using a Walkin/Walk-out (WiWo) method, where check-in-check out event is recorded by detecting direction of movement through certain corridor (faregate for example).

An alternative scheme to consider before a full roll-out of a BiBo is Check-in/Be-out (aka Assisted BiBo). Instead of fully automatic check-in, the CiBo scheme requires passenger to confirm within the smartphone application that they have started their journey. Check-out is recorded automatically. Such scheme allows operators to gather and compare automatically recorded proximity recognition data with passenger confirmation data in order to assess accuracy of future BiBo scheme and adjust parameters if necessary.

There are two main technologies that have been tested in-depth for feasibility for a BiBo scheme:

Long-range RFID: Based on active RFID tokens replacing current passive, nearfield, smartcards and long-range sensors placed within vehicle.

ADVANTAGES	DISADVANTAGES
The technology has been proven for decades to work in most urban environments successfully.	Cost of the complicated hardware installation and active (battery-powered) RFID tags (tokens) that must be distributed to passengers make the technology financially infeasible for most PTOs
RFID technology can be cross-utilised in gated and non-BiBo environments.	Inferior user experience due to lack of communication to passenger about successful or unsuccessful check-in/check-out event and fare calculation.

Bluetooth Low Energy (BLE) beacons: Technology is based on BLE beacons that are placed within vehicles to transmit localisation data over Bluetooth protocol. This signal can be received by passenger's own smartphones, which run a mobile ticketing application performing passenger localisation and fare collection duties for the BiBo scheme.

ADVANTAGES	DISADVANTAGES
BLE protocol is widely available and supported by all smartphones on the market, thus supporting a cost-effective widespread roll-out of a BiBo scheme..	Missing unified BLE beacon communication and proximity detection standard for all phone manufacturers to follow. This makes BLE-based BiBo schemes still too unreliable for commercial roll-out.
Smartphone-based BiBo scheme enables proper communication to passengers regarding check-in/check-out events and fare calculation.	

When ultimately succeeded, a well-established BiBo scheme could be considered an ultimate fare collection solution that both passengers and operators greatly benefit from. But there are key points to consider:

- BiBo scheme requires an account-based fare collection back-end to be implemented.
- BiBo scheme requires vigorous testing and pilot period before full commercial roll-out.

Adoption and trust of BiBo by passengers will take time, thus they should be taken as a complementary early-stage solution to existing traditional fare collection schemes.

BANK CARD AND MOBILE PAYMENT SOLUTIONS

Latest Open Payment schemes that are already in use in several countries – such as contactless credit cards, NFC enabled smartphones with credit card emulation or payment apps offered by the industry – can now be used to purchase tickets. This trend can be observed, in particular, in areas where paying with credit cards and using online payment methods are already very common. Convenient use in combination with high security levels are the most important advantages.

This is pretty obvious: Passengers can use public transport without additional hurdles. They do not have to install an app first or buy a smartcard, they can simply use a medium that they already possess and are familiar with, and they don't have to worry about potentially unused credit balances.

Only when a system is fully open loop can the transport company save the administration costs for its own media and the complex management of remaining credit balances. If the open loop system is associated to a closed loop system, there is an increase in costs.

Open Payment options can very easily be integrated into ID-based ticketing systems due to the similar technical approach. Nevertheless, Open Payment solutions require the deployment of a dedicated acceptance network based on EMV standard which is added to the "traditional" ticketing network. It also means that the infrastructure and the back-office must be compatible with EMV requirements, which can be expensive. Moreover, all validation data are known by the bank issuer.

This chapter throws light on three payment methods that have meanwhile proven their capability to purchase tickets in a reliable, secure and convenient manner.


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cEMV (open loop)

EMV stands for Europay, Mastercard and Visa, the companies who developed the technical specifications for this global payment standard. From a technical point of view, it is a method that makes sure smartcards and payment terminals are compatible.

For years the card-based EMV standard has been established. The card uses an embedded microprocessor to communicate with an EMV Point of Sale unit. At the beginning the card had to be inserted into the unit, meanwhile a contactless tap is sufficient, indicated by cEMV.

The standard used for the contactless communication is NFC (ISO 14443) short range radio, a standard that is widely spread in this kind of applications.

Regarding the use in public transport there are three models in use:

- **Single Tap, also known as Pay-as-you-Go**. This model is based on a fixed fare tariff (flat fare), that is automatically charged after tapping the card at the validator. As there is no fare calculation needed, this model can run without an account based back-office system.
- **Aggregated model** that is technically more complex. Within this model, a more complex tariff can be applied, as well as combined use in a multimodal environment. The basic differences to the single tap model are the tap-on / tap-off scheme, that is necessary to calculate the tariff, and the post-paid scheme. All taps registered on an account in the back-office system, where the tariff for every journey is calculated and invoiced to the user at the end of the month. As the account registers multiple journeys and frequent use, the system can be combined with certain customer loyalty programmes or best price models.
- **Pre-purchase model**, that links a ticket purchased before the journey to an account that is associated to a card. For the purchase-process there are variable options, an online purchase is widely in use. With the first tap at the beginning of the journey the ticket is validated.

Visa and Mastercard have created a specific contactless payment type for public transport, called Mass Transit Transaction or Contactless Transit Aggregated Transaction respectively. This payment type allows to manage contactless payments regardless of the PTO's size or fare structure. It also provides the framework for features like capping, debt recovery and so on.

The Visa or Mastercard labelled bank card is tapped on the validator according to the payment specification and is always handled offline, as the boarding speed is one of the most critical concerns for public transport in cities. Also, the data connection stability cannot be guaranteed in a moving vehicle.

In the meantime, besides the physical cards, virtual smartcards and virtual credit cards on NFC-enabled smartphones are more and more in use and allow an even more convenient use of cEMV.

Apple Pay

Apple Pay is a payment system of the US company Apple that can be applied on Apple´s NFC-capable mobile devices by using the ´Wallet´ App or within Web applications by using the ´Safari´ browser. The system was launched in September 2014.

The communication with field devices is based on NFC technology. For every transaction a so-called Device Account Number is transmitted to the seller. This number is instantly generated, represents the credit card number and can be seen as a token. The number is stored in the Chip secure element and is therefore separated from the operating system. It is not part of the systems´ backup. If the user wishes to do so, he can delete the number from his device.

After having received the Device Card Number the system checks if the number fits to a valid credit card number that is deposited in the bank network. The seller transmits the number to the associated bank network and receives a confirmation for the transaction. Afterwards he sends the payment amount and his ID to the customer´s device. In a second step the customer has now to confirm the transaction using his Touch ID or his Apple watch. The confirmation contains an encrypted set of data comprising a unique card validation code (CVC), the payment amount, the seller and the authentication of the Apple-pay-user at his specific device. Via the seller this cryptogram is transmitted to the bank network and the payment is accomplished.

The entire transmission process does not contain any real credit card number or any sensitive data. The Device Account Number can only be used with a valid cryptogram and can only be used with a single specific Apple device. According to Apple, the necessary card data for the transaction are neither stored on the device nor on Apple´s servers. The real credit card number therefore is not visible to anyone who is part of the transaction.

Android Pay

The payment service Android Pay was launched at the end of May 2015 by Google. The service can be used with an NFC-enabled smartphone with the Android version 5.0 Lollipop or higher.

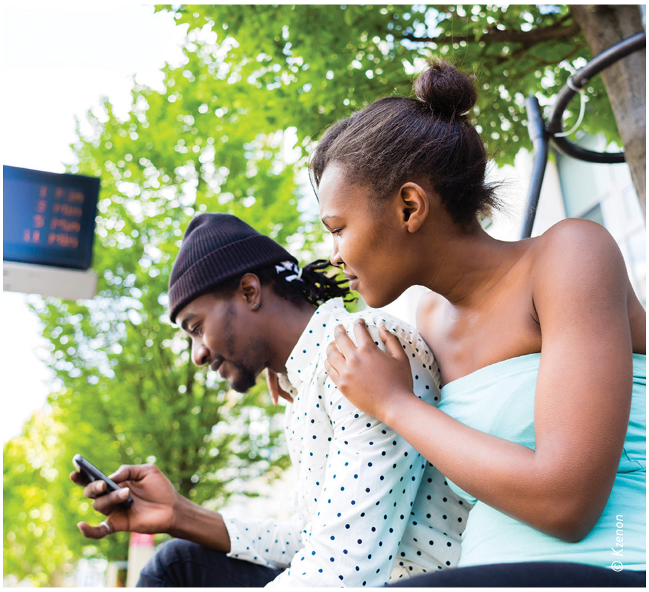
Unlike other services like Apple Pay, Android Pay was designed as an open system. It is thus universally applicable and supports the smartphones of different manufacturers. In addition, Google leaves it to the users whether they want to use Android Pay directly as a Google service or indirectly as a separate app of their bank.

Users must once deposit online their credit card data or personal data (if using their mobile phone bill for accounting) or link a PayPal account. This data is stored securely and transmitted within a transaction only in the form of virtual identification numbers (tokens), therefore the real credit card data is not exchanged with the payment terminal of the app and thus staying invisible to the merchant.

Additional protection is provided by the HCE. This solution is designed like a physical security chip but using software only. Thus, the security level can be updated at any time and independently of the device.

Once the registration has been made, it is no longer necessary to enter credit card information when using the service. Upon completion of the transaction, the user receives a message on his smartphone.

Android Pay can also be used through third-party app services that integrate the Google Payment API.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Compatibility of pricing policy with mobile ticketing solutions

Pricing policy / Mobile ticketing solutions		SMS	1D 2D BARCODES	BLUETOOTH	NFC MOBILE TICKETING SOLUTION	PAYMENT SOLUTION – EMV STANDARD
Pre-purchase	Single ticket	●	●	●	●	●
	Season ticket		●*	●	●	●
Pay-As-You-Go				●	●	●
Post-payment (account with (means of payment			●*	●	●	●

* Combined with additional security elements

Main characteristics of mobile ticketing solutions

Mobile ticketing solutions / Other considerations	SMS	1D 2D BARCODES	BLUETOOTH	NFC CLOSE LOOP	OPEN PAYMENT	BIBO
Compatibility with contactless transit equipment	-	-	-	++	-	-
Ticket inspection procedure	+	+	++	+++	++	X
Customer experience	+	+	X	+++	on mobile +++++	++
Security	+	+	X	+++	+++	X
Level of mobile coverage	+++	+++	+++	++	++	+++

- Not applicable X Not available yet + level of implementation

FARE MODELS AND POLICIES

FARE SYSTEM SELECTION

In public transport, there is a variety of fare models in use depending on different schemes of operation. The different models mostly try to reflect the actual costs of providing service, which constantly fluctuate throughout the day. Peak period operation, longer trip routes, and premium services all cost the PTO more money to operate and require more capital investments. Additionally, there is the issue of cross-subsidisation; since flat fares do not distinguish between time, type, or distance of travel, users traveling shorter distances, during off-peak hours, and using non-premium services cross-subsidise riders on more expensive routes.

Having this in mind, the different models have several dependencies and as well several advantages and disadvantages. To assess alternative fare models, the following criteria may be considered:

- **Ease of user understanding**: To speed up fare transaction time and to minimise disputes between staff and passengers, a simple system is preferred. The simplest system is a flat fare or time based fares. Distance based fares are easier to understand for local people but potentially confusing for occasional travellers or visitor. They are often perceived as being the most equitable model. Zone based fares are well understood if the number of zones is limited.
- **Ease of fare collection**: The simpler the fare system, generally the easier the fare collection process.
- **Selection of fare zones**: A system with too many zones is less easy to use and understand. The location of zone boundaries is important. Once boundaries are set, they are virtually fixed. The strategy is to define boundaries that are reasonably equitable for all users yet optimise revenue.

DISTANCE-BASED

Distance-based fare models provide a closer association between price and distance travelled than other systems, with the price per kilometre typically 'tapering' with distance. This aligns price with the cost of service provision and so strikes a balance between consumer and

producer interests. In this system, each route has a series of distance-related 'fare-stages' and payment varies according to the number of 'stages' travelled. Usually there is no facility for transfer tickets, with separate fares for each vehicle boarded. However, unless the degree of taper is extreme, the price penalty on transit is relatively small. Distance based models generate an extensive number of fares across a network and even an extensive range of fares within one long route. As with other fare systems, the number of fares increases when special conditions apply for particular user groups, such as students or pensioners.

ZONE-BASED

Zone-based fare systems are a combination of both flat fare and distance-based systems. They are common in many cities worldwide with fares related to the number of zones crossed on a journey. Compared to distance-based models, zone-based fares have the advantage of having fewer number of fares, whilst fares are still broadly related to the distance travelled. The challenge, especially for non-local passengers, is that to buy the correct ticket you must know which zone your destination stop is in.

The zones are typically concentric rings around the central business district that acts as the attractor for the majority of commuter trips. However, some larger cities have additional travel nodes in the suburbs and subdivide the outer zone radially, to recover the cost of the resulting longer trips. Because zonal fares differ depending on the number of zones crossed, tickets are for one, two or three zones etc. Short trips across a zonal boundary may be penalised unless a special short distance fare is available.

Zonal fares require care in siting the zonal boundaries. It is difficult to change boundaries once established. Where a boundary is at, or close to an important traffic generator (major market, hospital or college), there may be a marketing advantage in providing a zonal overlap for the generator, so that trips to it from both zones are at the single-zone fare.

The attraction of zonal fares is that they enable some fare discrimination between long and short distance travel, yet are not as complex as stage fares. However, there can be a high price penalty for route interchange, unless the main interchanges are at zone boundaries with overlapping zones. Changing to zonal fares requires high quality support and publicity to familiarise all users with the system. This should include a simple map or schematic illustrating the zones and what the fares between zones. Zone number should be indicated on each stop.

USER-BASED

User-based fare models are typically combined with other fare models. The passenger groups can have a wide variety (children, adults, students, elderly, people with disabilities, occasional or frequent users, passenger groups, and others). For each passenger group a further subset of tariffs can be offered (e.g. adult´s day passes or student´s monthly passes).

TIME-BASED

Time-based fare systems allow passengers to ride a network and make free transfers for a set amount of time from initial boarding. The tickets can be anything from an unlimited weekly pass to an unlimited monthly pass, to even shorter periods of time, such as a free transfer within a one- to two-hour time period. This scheme may be used to address the problem of the onward validity of tickets for journeys on two or more vehicles, to reduce the price penalty of an interchange. The model is typically suitable for a densely served network, where connection times are short. A time-based fares system requires some sort of physical token or card (paper ticket with a barcode, magnetic or smart card or similar) and on-board validation equipment or at least validation equipment at every stop to issue the transfer.

PAY AS YOU GO

Pay as you go is typically not a fare model, but a payment method where credit is purchased in advance and stored on a stored-value card. The credit can be used in small amounts and topped up when required. Used especially for mobile phones and transport ticketing.

Latest developments in payment allows this method to be used also with a contactless bank card. In this case the fare is deducted directly from person's bank account.

BEST FARE CALCULATION

In terms of service orientation, the PTO can take things a step further and offer its customers the best fare calculation. This ensures that passengers always pay the most favourable price for their journey. They simply validate their card at each entry. If the journey should reach a determined cap, the system automatically ensures that charges will be made only up to this limit (fare capping). The caps can apply for different types of tickets (e. g. daily or monthly tickets). Some systems even allow users to set additional, freely definable time periods. Consequently, some transportation companies don't continue the sale of stripe cards, daily, or monthly passes. This can provide exceptional convenience because the passengers no longer have to think about which product is best for them. The ticketing system automatically calculates the best price. Incidentally, this is also more socially equitable for lower-income individuals who have been reluctant in the past to purchase a monthly ticket which at the end would have been the most economical.

MILAN, ITALY

In June 2018, Milan introduced cEMV payment in all metro stations. Enabling those in possession of a contactless-enabled credit card access without any additional operations or service subscription. The new system automatically calculates, based on entry and exit, the cost of the ticket, always charging the most convenient rate, even for extra-urban subway routes and day tickets. For example, after the third subway trip on the urban network, the day ticket is automatically activated. The service does not include additional costs.

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However, although being very passenger-friendly, implementing the Best Fare Calculation usually means losing ticketing revenue, as travelers only pay for the journeys they actually make, while in a models with period passes the average number of actual journeys tends to be lower than the calculated price of the pass.

There is also an issue of deferred revenue, as the payment for taken journeys is received gradually over a longer period of time, while period passes are paid in advance, which means the PTOs are collecting the revenue sooner, than the Best Fare model.

PROCUREMENT MODELS: OWNERSHIP VS SOFTWARE AS A SERVICE

Although the formal ownership of a ticketing system still lies with PTAs in many instances worldwide, the account-based principle and cloud services are rapidly changing that paradigm. As the ABT system is becoming more and more a serial product, rather than a specially developed solution, the idea of handing over the intellectual property rights of the source code, is unacceptable for most of the suppliers.

Instead the Software as a Service principle is becoming a new de facto standard in the ticketing industry. There are several benefits of Software as a service (SaaS), compared with the ownership of the traditional locally hosted ticketing system, for example:

- Low TCO (total cost of ownership)
- Constant upgrades and improvements, the system never gets obsolete
- Seamless scaling possibilities
- Dedicated hosting environments usually provide better uptime and security, than locally hosted service

The most common reasons for mistrusting the SaaS model in public transport ticketing are fear of a vendor lock and insecurity about the supplier's ability to support the system during the whole contract period. Moreover, PTAs usually have a vision of developing the system further by adding functionalities and keeping up with general evolvement of the technology and there can be strong belief that such extra developments would be very costly, if provided by the same supplier.

However, it needs to be considered that even if the IP rights would allow the PTA to procure the development from third parties, it usually concerns only either customer facing applications – web portals and mobile applications – or completely new functionalities, which are added to the existing system by API integrations.

As the core ticketing system architecture, source code and business logic are still very vendor-specific, then it is not feasible to assume that a random third party could actually develop the system further without extensive support from the initial supplier.

There are initiatives to standardise different parts of the ticketing solution, which could help to avoid vendor lock situations, such as:

- ITxPT: standardised communication protocols and hardware interfaces for vehicle onboard equipment
- BoB (Billjet- och Betalstandard): Swedish national standard for ticketing and payment in public transport
- Keyple: An open source SDK developed by CNA and property of the Eclipse open source foundation, Keyple avoids by proposing an API with a library of functions, a lock-in from vendors and also opens ticketing to a wide range of new actors

Often an Escrow method is used for securing the PTAs ability to keep supporting the current SaaS model ticketing system even in case of supplier's bankruptcy. It means that the source code of the system would be stored in the independent code storage and the PTA would gain the right to use the code if the supplier fails to fulfil the contract.

CAPEX/OPEX MODEL

Capex/Opex is the most commonly used contract model for public tenders. In many occasions the part of the funding is provided by public structural and investments funds and the prerequisite for receiving the grant is gaining an ownership of some part of the procured system, rather than purchasing service only.

Usually the Capex side of the contract consists of needed hardware (onboard and offboard – vending machines, inspection devices etc.) with installation and initial setup of the ticketing system for launching the service. The Opex part then consists of recurring fees for licences, hosting, maintenance, service and support. Key points to consider:

- With the Capex/Opex model the purchaser will have the ownership of the hardware and in some occasions also other parts of the system.
- There is a need of sufficient funds for one-off payment after the delivery of hardware and launching the system.

FULL OPEX (RENTAL) MODEL

As the operation is partly funded by the ticketing revenue, the full Opex model would allow distributing the ticketing system implementation costs to the whole contract period and plan the budget for the coming years accordingly. The Opex model also provides stronger position for the PTA when negotiating over possible faults or misdoings in the system and service.

On the other hand, as the supplier has to postpone the reimbursement for implementation costs, it may need an additional funding from financial institution, making the overall delivery more expensive. In most of the cases the WACC (Weighted Average Cost of Capital) of the PTA is cheaper, compared to any private company, due to the element of equity requirements by shareholders and regular access to capital costs. Key points to consider:

- The Opex model is financially suitable for smaller tenders where the cost of capital does not influence the contract value in a large scale.
- The ownership of the equipment and the system remains with the supplier, at least until the end of the contract. Possible handover after the contract period is subject to the terms and negotiations.

REVENUE SHARING MODEL

In the revenue sharing model, the supplier of the ticketing system would get a fixed percentage of the periodical (usually monthly) ticketing revenue to cover the delivery. It is similar to the Opex model, but involves more risk for the supplier, as the local revenue collection rules and regulations, but also the enforcement activities, are not under the control of the supplier. As the public transport in general tends to be a highly political topic, the risks of drastic changes in the basics for the revenue collection – ticket prices, entitled passenger groups, etc. – could be very high.

On the other hand, for the PTA it is a risk-free business model, as it considers the fluctuations in revenue collection and therefore provides financial relief if the ticketing revenue goes down.

The revenue sharing model is not a common policy and does not provide transparency for the actual contract value. Key points to consider:

- Due to the high (political) risks, the tender participation interest may be low and limited only to a small number of possible suppliers. This may lead to compromises in the technological level of the ticketing system and compliance with initial requirements.

FULL CAPEX MODEL

This is the most uncommon business model. It is not rare for the implementation costs to be invoiced as a pre-payment prior to the system launch or even before the delivery of the equipment, but as with the SaaS approach, the monthly fees for hosting, licences and support are usually paid out periodically (Capex/Opex model), rather than in advance.

However, in some occasions there may be specific funding reasons – availability of the budget, received grants etc. – which encourage covering such periodical fees for the whole contract term as a part of the Capex payment. The full Capex model could also be used for supplier's financial risk mitigation, when delivering to authorities or regions without sound financial background.

Key statements to consider:

- There is a need of sufficient funds for a one-off payment for the whole contract value;
- The purchaser does not have any leverage against the supplier, in a case of possible failure in delivery.

5 UITP, 2019. Mobility as a Service. Report.

ADAPTATIONS TO NEW PUBLIC TRANSPORT BUSINESS MODELS

MOBILITY AS A SERVICE

For a MaaS system to be functional, the MaaS provider needs ticketing data as one of the key datasets from participating operators[5]:

- **Transport data:** Data on the availability of the mobility service, real-time data via secured APIs
- **Access/ticketing data:** Data to resell the access to the mobility service, mobile ticketing, online booking through secured APIs.
- **Travel data:** Private data on the traveller is needed to clear them for the use of the mobility services (e.g. driving license for Car-sharing).

Not all operators have this data available in the required format. Questions on financing of the adaptation of data and APIs arise. Most transport operators are concerned about losing the customer relationship if they open their data, especially ticketing/access to APIs. Indeed, they need to have full trust that the MaaS provider will give a qualitative service to their clients. The fear to lose control and contact with the customer is a barrier to building MaaS. Thus the real question is less about opening data and more on how to share the customer.

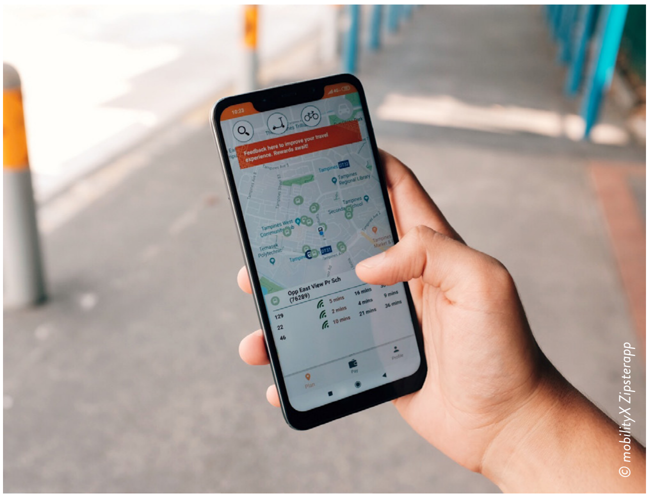
Building Trust: Data sharing concepts & algorithms

Transport operators might feel reluctant to open their data to MaaS integrators, as they see different risks:

- The first perceived risk is related to **losing the customer relationship.** Community building and customer care are essential to the success of the service and yield management.
- The second risk is that if the MaaS offer is successful, the MaaS provider would become the **gatekeeper to all demand and usage data.**
- The third risk all transport operators face is **disclosing the business model**. By sharing the availability data their business model becomes visible to competitors and to other businesses who might enter the market on the basis of that data.
- The fourth perceived risk is linked to the **use of independence of the algorithm**. How can transport operators ensure that the integrator will not prioritise one or the other transport solution according to its own interests?

In order to build the trust needed among all partners, these risks need to be addressed. This can either be done by:

- The MaaS integrator proposing fair business rules, meaning terms and conditions for the reselling of the transport services.
- A clear re-selling contract such as a share-alike license set by the transport operators.
- Regulation.



The integrator needs to find a way of enabling the transport providers to keep their customer relations. Regarding demand and usage data, there are two visions: one where this information is shared back to the operators and one where it would be sold to those that pay the highest price. To build the needed trust, customer and usage data should be shared by the MaaS provider with the transport operators as it empowers the whole ecosystem and contributes to build better cities, which in return is beneficial to the MaaS service. This would also build on the reciprocity principle in the opening of data.

Regulation and standards

The quality and consistency of shared data and the data format are essential for MaaS. A standard to share data should be set up, to which every actor could adopt voluntarily. Forcing transport operators to open their booking and/or ticketing via regulation is difficult as it will not necessarily adress the above-mentioned risks. Therefore, it will not help to build the solid partnership that is needed to create a successful MaaS.

> *“There needs to be a collaborative approach as setting up a MaaS solution is all about cooperation.”*

New forms of regulation, such as the possibility that public authorities establish a 'public data cache' for mobility data and regulate input and output, should be taken into consideration. Therefore public authorities need to have the necessary capabilities and resources to understand and manage the risks and stakes from an IT and data analysis perspective. It is also essential that data is shared back to authorities in order to enhance overall mobility coordination and planning.

DEMAND-RESPONSIVE TRANSPORT

Today, when we speak about demand-responsive transport (DRT), of which there are roughly 150 different types, we quickly turn towards ridesharing. Ridesharing can be in the form of car or van pooling, ride-hailing, or peer-to-peer arrangements. Here we focus on public fleets of vans (or shuttles, with 6-12 seats) especially designed for ridesharing, coordinated in a central place, and operating in or between specifically assigned areas, at certain periods of the day, and often embedded in the public transport network such as BerlKönig (Berlin), IsarTiger (Munich) and SSB Flex (Stuttgart).

In almost all cases, the booking is done via an organisation app which means that there is no travel entitlement in the classical sense, it is just payment (not ticketing). The customer must have an account in which a valid means of payment is submitted. The payment model can take any modern form: one-off-payment, pay-as-you-go, up to subscription models with monthly billing. We also see the use of public transport tickets, i.e. integrated in the fare structure. In addition, the app may ask for a name, email, mobile telephone number, special needs, preferences, and an opt-in to use the data for anonymous analyses to improve these services.

In principle, the only required input for booking a ridesharing service is the (approximate) destination! The app will reply with the closest pick-up point (often based on the coordinates of the booking device) and an appropriate pick-up time. And of course: the drop-off point, approximate arrival time, and price (plus maybe a something to identify the vehicle, the name of the driver, etc).

- Additional options may include variables such as: Number of passengers, luggage, animals, PRM, etc. Moreover, the customer could indicate further preferences, such as a specific driver, gender of the fellow passengers and so on.
- In addition, the service level agreement will have defined: Minimum head time to order a vehicle; maximum waiting time for the vehicle to actually depart; maximum travel time to destination.
- The use of the app may be subject to age restrictions and require consent.
- The pick-up & drop-off points can be regular public transport stops, but in addition, a great number of 'virtual stops' are defined. These can be street corners or other places easily identified. They are also based on a direction of travel to accommodate efficient routing.
- Note: Pudos make ridesharing a different system from taxis as it is not a door-to-door service! The pudos can be several walking minutes away from the customer's position.
- The customer can be updated shortly before the expected departure time and informed once the vehicle has arrived.
- Should a passenger not appear for pick-up, the trip is continued after a short time, and usually the normal price is due.

In general, the price for a ridesharing trip lies between the price of a similar trip with public transport and a taxi ride. Usually the price is fixed through the booking.

- There can be a minimum or a boarding price. At the same time, the price can be variable: distance based, on/off peak, specific corridors (e.g. airport-business district), selected pick-up and drop-off areas, or special prices.
- The final price can also be less, for example when service level agreements were not met, but also the number of (additional) fellow passengers can still reduce the price. There are no examples (yet) where the price can also be higher, for example due to congested traffic conditions as can be the case with taxis.
- Thus far it is unknown whether reductions for e.g. children or elderly exist.

A breakthrough of ridesharing is expected to occur when vehicles become autonomous. More so even than with buses, the cost of the driver is relatively high.

DISTRIBUTED LEDGER TECHNOLOGY (BLOCKCHAIN)

With blockchain, an innovative technology enters the ticketing eco system. What does Blockchain mean? Blockchain, the technology behind Bitcoin, is an example of a distributed ledger technology (DLT). A DLT is a virtually organised database or ledger, maintaining a permanent and tamper-proof record of transactional data. It is managed by computers allowing a peer-to-peer (P2P) network, whereby each of the peers (computers) in the network maintains a copy of the ledger. Peers can add new transactions to the block if they comply with previously agreed protocols (rules). All copies are updated and validated automatically and simultaneously. The value of blockchain for ticketing lays in the possibility review the management of some of the current operational challenges of scheme like procuring an entitlement, accessing a service, inspection, revoking entitlements and others that will be investigated in future. The work is only in its early stage and the way these use cases can be reorganised with blockchain is under investigation.` A UITP working group is currently examining the cases.

CONCLUSION

Ticketing and payment systems are key elements of a public transport system. The huge installed base such as infrastructure (front-end devices and back office) or fare media are embracing various generations of technologies and architectures. New demands for both an improved customer experience (multimodality, interoperability, etc.) and maintaining new public transport business models such as MaaS, DRT and others are requiring future-proof solutions which must be easy and fast to use and accessible to all, regardless of the medium they carry with them. All this leads to two key challenges: Firstly, understanding what technologies are available and required and, secondly, how to handle the transition from a legacy to a new environment.

WHAT TECHNOLOGIES ARE AVAILABLE AND REQUIRED?

As described in the previous chapters, various proven concepts and solutions are on the market. For a local public transport service provider, a state-of-the-art ticketing system must be flexible, open, expandable and economical. Flexible for easy introduction of fare changes and to shorten time-to-market for new fare products, which meet future market demands. Open and expandable for easy integration of new modes, business models, schemes, media, services, vendors and sales channels as well as for geographic and organisational expansion. Economical for offering a changing demand for lower OPEX/CAPEX.

The use and introduction of standards, open interfaces, open access to API's and multi-vendor-model options are crucial to achieve these characteristics. From a today's perspective, ticketing systems based on open standards and open APIs, with an intelligent balance between media-centric and account-based architectures, and the integration of media such as open-loop contactless cards, contactless EMV credit cards, mobile NFC are forming an environment which offers both the local public transport service providers and their customers an affordable, secure and convenient service they are expecting.

FROM LEGACY TO A NEW ENVIRONMENT: TECHNICAL AND COMMERCIAL ASPECTS

The implementation approach shall consider the technical practicality, the commercial impact of a further usage and integration of existing components and the benefit of a smooth and convenient transition for the users, but also possible the drawback from an extended project implementation time as well as one-off integration efforts. On the other hand, a sharp cut-off of the existing implementation requires extensive planning, testing and preparation and is carrying a bigger risk but also the benefit of an earlier end of supporting a legacy environment. All these aspects require an individual validation, where criteria such as network size, age and type of a legacy system, and technology, play a crucial role and often lead to a gradual go-live and parallel operation of the existing and new solutions.

The commercial approach shall answer the question under which business model the selected technology shall be procured, contracted and operated, ideally to the benefit of both the buyer and the vendor. In an environment where infrastructure investments for such ticketing solutions are funded by public funds, a CAPEX/OPEX model, covering hardware (onboard and off-board – vending machines, inspection devices etc.) with installation and initial setup of the ticketing system under CAPEX and other parts such as recurring fees for licenses, hosting, maintenance, service and support under OPEX, is widely common, as the risks and commercial exposure between buyer and vendor are balanced.

Other models such as a full OPEX (rental) model or a revenue sharing model are offering potentials for the buyer to optimise and stretch their exposures over a longer period of time up to the full lifetime of the solution to implement. At the same time, vendors need to shoulder a risk, which most of them can hardly fully predict, carry and afford. This will lead to both - additional costs vendors need to factor in their offering and in limiting the competition landscape.

The commercial setup shall maintain a balanced, transparent, predictable and attractive business for both the buyer and supplier. This requires an individual validation but ensures the environment where both parties are interested and able to support a continuous, long-term development of new services their customers are demanding.

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ANNEXES

RELEVANT STANDARDS

Smart Ticketing is currently governed by the following International (ISO) and European (CEN) Standards:

- Media: ISO 14443
- CEN/TS 16794 Edition 2
- File Structure: ISO / IEC 7816-4
- Secure Element Security: ISO 15408 (Common Criteria)
- Roles and Use Cases: ISO 24014 Part 1
- Part 3 (IFM) / STA use case document
- Transport Applications: EN 15320 (IOPTA)
- Transport Data Elements: EN 1545
- STA Reference documents
- All standard can be bought from the ISO store or the relevant national standardisation bodies

GLOSSARY OF TERMS

1D	**One-dimensional**
2D	**Two-dimensional**
ABT	**Account-based ticketing** A fare-collection system in which the proof of entitlement to travel and any records of travel are held in a back-office (i.e. servers) and not necessarily on any physical media held by the passenger. ABT differs from traditional card-based schemes because the business rules and fare calculation are managed in the back-office and the fare is calculated and billed after the trip is complete. This means that the fare-media used to tap in and out of the system is nothing more than a unique identifier for the customer linked to their account.
API	**Application programming interface** An interface or communication protocol between different parts of a computer programme intended to simplify the implementation and maintenance of software.
App	**Application Software** A programme or group of programmes designed for end-users.
Aztec code	A type of 2D bar code
Bar-code	A method of representing data in a visual, machine-readable form.
Bi-Bo	**Be-in – Be-out** Validation system whereby the physical validation infrastructure within transport vehicle automatically detects the appearance and disappearance of a specific electronic token carried by passengers, without them needing to take any specific action. It enables a truly “hands free” travelling experience.
BLE	**Bluetooth Low Energy** Formerly known as “Bluetooth smart”, provides a good communication range but with reduced power consumption.
Capex	**Capital Expenditure** Cost of developing or providing non-consumable parts for the product or system.
Ci-Co	**Check-in – Check-out** Also called Tap-in/Tap-out or Touch-in/Touch-out, customers present their fare media/token to a specific Media Acceptance Device (MAD) / validator that uses a short-distance reader to check the passenger in to the transport vehicle/network.

Closed loop	A payment instruments that are used solely for transit purposes. That means, that such payment instrument can be used only for services provided by the transit Authority or Operator and not for generic payments outside transit. The transit Authority or Operator has the governance of the system
Contactless smart card	A smart card is a device, generally bank card size (standardised format), made of an embedded integrated circuit encapsulated in a plastic body. The contactless smart card communicates with and is powered by the reader through radio-frequency (RF) induction technology, within a few centimeters distance. It is a miniaturised computer with its own computing power and applications.
CNA	**Calypso Networks Association** Calypso Networks Association
DLT	**Distributed Ledger Technology** A virtual organised database or ledger, maintaining a permanent and tamper-proof record of transactional data.
DRT	**Demand-Responsive Transport** Public fleets of vans (or shuttles, with 6-12 seats) especially designed for ridesharing, coordinated in a central place, and operating in or between specifically assigned areas, at certain periods of the day, and often embedded in the public transport network.
Escrow	Contractual arrangement in which a third party receives and disburses money or property for the primary transacting parties according to conditions agreed by the contracting parties.
cEMV	Contactless EMV
EFM	**Electronic fare management**
EMV	**Europay, Mastercard, Visa** EMV stands for Europay, Mastercard and Visa, the companies who developed the technical specifications for this global payment standard. From a technical point of view, it is a method that makes sure smartcards and payment terminals are compatible.
GDPR	**General Data Protection Regulation** Regulation (EU) 2016/679 (GDPR) is a regulation in EU law on data protection and privacy in the European Union (EU) and the European Economic Area (EEA). It also addresses the transfer of personal data outside the EU and EEA areas. The GDPR aims primarily to give control to individuals over their personal data and to simplify the regulatory environment for international business by unifying the regulation within the EU.
GSM	**Global System for Mobile Communications** Otherwise known as cellular phone technology
GSMA	**GSM Association** The association which represents the interest of mobile operators worldwide, uniting nearly 750 operators with almost 350 companies in the broader mobile ecosystem www.gsma.com
HCE	**Host card emulation** This technology developed by Google and available on Android phones uses a software security domain to store sensitive data by opposition to solutions using a hardware component (SIM or SE).
ICT	**Information and communication technology** An extensional term for information technology (IT) that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals) and computers, as well as necessary enterprise software, middleware, storage, and audio-visual systems, that enable users to access, store, transmit, and manipulate information.
IP	**Intellectual Property** It is a category of property that includes intangible creations of the human intellect.
ISMS	**ITSO Security Management Service** This enables ITSO-compliant smart ticketing systems to be set up, guaranteeing high security surrounding the data it processes.

Machine learning	The scientific study of algorithms and statistical models that computer systems use to perform a specific task without using explicit instructions, relying on patterns and inference instead. It is seen as a subset of artificial intelligence.
Magstripe	A paper ticket or plastic card featuring a band of magnetic material on which data can be stored and read by a machine.
MBT	**Media-based ticketing** System whereby a card (or other medium) is used as the travel entitlement, as opposed to a physical ticket.
MAD	**Media acceptance device** Ticket validator
Mobile ticketing	Process whereby customers purchase and validate tickets using mobile phones instead of a physical ticket
MaaS	**Mobility as a Service** The integration of, and access to, different transport services (such as public transport, rid-sharing, car-sharing, bike-sharing, scooter-sharing, taxi, car rental, rid-hailing and son on) in one single digital mobility offer with active mobility and an efficient public transport system as its basis. This tailor-made service suggests the most suitable solutions based on the user's travel needs. MaaS is available anytime and offers integrated planning, booking and payment as well as en route information to provide easy mobility and enable life without having to own a car.
NFC	**Near field communication** A set of communication protocols that enable two electronic devices to establish communication by bringing them within 4cm of each other.
Open-loop	In transport, an open-loop payments generally refer to the use of bank-issued contactless credit or debit cards (or other payment instruments), which can be used for generic payments also outside of transit. The finance sector has the governance of the system.
Open payment	In transit, an open payment means the use of any contactless credit cards, NFC enabled smartphones with credit card emulation or payment apps offered by the industry, to purchase the ticket.
Opex	**Operational Expense** An ongoing cost for running a scheme
PAYG	**Pay as you go** Fare payment type, where a travel medium (most commonly a smartcard) is tapped at the time of entry and exit (if Ci-Co is implemented) and the fare is deducted from the tokenholder's wallet or bank account without the need for pre-purchasing a ticket.
PII	**Personally Identifiable Information** Also known as personal data, any information relating to an identifiable person
POS	**Point of sale** The time and place where a retail transaction is completed.
Pre-paid	The service is paid for in advance and typically stored on a medium until validation
Post-paid	The service is paid for after the journey has taken place
PRM	**Persons of Reduced Mobility**
PSP	**Payment service provider** An entity, that connects merchants to the broader financial system for accepting payments from customers. PSP-s connect merchants, consumers, card brand networks and financial institutions.
PTA	**Public transport authority**
PTO	**Public transport operator**
Pudos	**Pick up and drop off points**
P2P	**Peer to peer**
QR code	**Quick Response code** Matrix barcode, or two-dimensional bar-code with its machine-readable optic label which contains the data.

Ridesharing	On-demand ridesharing (also referred to as microtransit, ride-pooling, app-based on-demand buses/shuttles/minibuses, mini-bus taxis, etc.) is an IT-based shared transport service operated by a company with professional drivers with no fixed schedule, not necessarily fixed stops and dynamic routing. Vehicles can range from cars to large SUVs to vans to shuttle buses. On-demand ridesharing serves multiple passengers independent from each other using dynamically generated routes, and may expect passengers to go to common pick-up or drop-off points. It is either run as a complementary service to public transport or in competition with existing public transport lines by private companies.
Ride-hailing	Ride-hailing, or "transactional platforms for the ride-selling" or "ride-selling" are mobile applications that match customer demand for a ride with private drivers or drivers of vehicles for hire through GPS tracking. Other terms used in the literature are "ride-sharing apps", "Transportation Network Companies" (TNC) or applications for "ride sourcing".
RF	**Radio frequency**
RFID	**Radio Frequency Identification** RFID uses electromagnetic fields to automatically identify and track tags attached to objects.
SAAS	**Software as a Service** A software licencing and delivery model in which software is licensed on a subscription basis and is centrally hosted. It is sometimes referred to as "on-demand software.
SDK	**Software Development Kit** A collection of software development tools in one installable package.
Smartcard	A smartcard is a device, generally bank card size (standardised format), made of an embedded integrated circuit encapsulated in a plastic body. In transit, smartcards are used to control access to a transit network
Smart Ticketing Wallet	Also known as e-wallet – an online service, that allows individual to make electronic transactions. In transit it refers to a digital wallet, which holds passenger's funds, eligible to purchase of transit services
SE	**Secure element** Solution where sensitive data are stored in the SE.
SIM	**Subscriber Identity Module** An integrated circuit intended to securely store the international mobile subscriber identity number and its related key which are used to identify and authenticate subscribers on mobile telephony devices.
SMS	**Short message service** A text messaging service component of most telephone, Internet and mobile device systems. It uses standardised communication protocols to enable mobile devices to exchange short text messages.
STA	**Smart Ticketing Alliance** www.smart-ticketing.org
TCO	**Total Cost of Ownership** A financial estimate intended to help buyers and owners determine the direct and indirect costs of a product or system
TMV	**Ticket vending machine**
UID	**Unique identifier** An identifier which is guaranteed to be unique among all identifiers used for the same purpose.
WACC	**Weight of Average Cost of Capital** The rate that a company is expected to pay on average to all its security holders to finance its assets. The WACC is commonly referred to as the firm's cost of capital. Importantly, it is dictated by the external market and not by management. The WACC represents the minimum return that a company must earn on an existing asset base to satisfy its creditors, owners, and other providers of capital, or they will invest elsewhere.

This is an official Report of UITP, the International Association of Public Transport. UITP has more than 1,800 member companies in 100 countries throughout the world and represents the interests of key players in this sector. Its membership includes transport authorities, operators, both private and public, in all modes of collective passenger transport, and the industry. UITP addresses the economic, technical, organisation and management aspects of passenger transport, as well as the development of policy for mobility and public transport worldwide.

This Report was prepared by the Information and Telecommunications Technology (ITT) Committee.
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